Title

Managing pain by visually distorting the size of a painful body parts. Is there any therapeutic value?

Authors

Priscilla G. Wittkopf [1, 2]

Mark I. Johnson[1, 2]

[1]Centre for Pain Research, Faculty of Health and Social Sciences, Leeds Beckett University, Leeds, UK

[2]Leeds Pallium Research Group, Leeds UK

Correspondence should be sent to: Professor Mark I. Johnson, Faculty of Health and Social Sciences, Leeds Beckett University, City Campus, Leeds LS1 3HE, United Kingdom

Telephone: +44 (0)113 8123858: Email: M.Johnson@leedsbeckett.ac.uk

Article category: Editorial

Financial support: The authors are currently delivering a programme of research in this area funded by funded by the Science Without Borders program, Government of Brazil.

Conflict of interest: The authors declared that there have no conflicts of interests regarding this manuscript.

Authors' contribution: Both authors contributed equally to the writing of the article.

INTRODUCTION

Painful conditions such as complex regional pain syndrome, phantom limb pain and low back pain may change the sense of body image, so that body parts are perceived as large, swollen, heavy, or stuck in one position [1]. In 1995, Ramachandran et al. [2] reported that phantom limb pain could be relieved by creating a visual illusion whereby the amputated limb appeared to be wholly intact by reflecting a non-painful intact limb in a mirror (i.e. using mirror visual feedback). Randomized, sham-controlled clinical trials of mirror visual feedback have confirmed the potential utility of the technique. For example, Chan et al. [3] assigned 22 patients with phantom limb pain to a four week course of one of the following interventions: viewing a reflected image of their intact foot in a mirror; viewing a covered mirror; or mental visualization. All patients receiving mirror visual feedback reported a decrease in pain (n=6) compared with only one patient in the covered-mirror group and two in the mental-visualization group. Three patients reported worsening pain in the covered-mirror group and four patients reported worsening pain in the mental-visualization group. Nowadays, mirror visual feedback, often termed mirror box therapy, has been incorporated within therapeutic programs to treat painful conditions associated with alterations of body image resulting from neuropathy [4] complex regional pain syndrome [5], fibromyalgia [6] and non-specific mechanical back pain [7].

DISTORTING THE SIZE OF PAINFUL BODY PARTS MODULATES PAIN

In clinical practice mirror visual feedback techniques tend to use reflections of normal sized limbs. This approach is beneficial for some but not all individuals and effects tend to be short-lived [8]. Recently, mirrors, lenses, binoculars and virtual reality have been used to distort the size of painful body parts in conditions with body image disturbances. Ramachandran et al. [6] described a single case where a mirror was used to 'resurrect' a painful phantom hand and a lens added to produce the illusion that the phantom hand had ‘shrunk’. This alleviated pain and the sense of swelling in the hand [6]. Moseley et al. [9] studied ten individuals with chronic painful and dysfunctional arms and found that magnifying their affected arm through binoculars increased movement-induced pain and swelling, whereas minifying reduced movement-induced pain and swelling. Diers et al. [10] investigated the effect of video feedback on chronic back pain in 18 individuals. The investigators magnified and minified views of the back whilst an investigator performed pressure algometry of myofascial trigger points on the back. They found that visual feedback of the back reduced stimulus-evoked pain but there were no statistical differences between normal and distorted views of the back. This approach is interesting because individuals rarely get sight of their own back in normal daily activities so visual feedback in this instance involved the unusual situation of observing one’s own back from a third person perspective. Preston and Newport [11] used real-time video capture techniques to distort the appearance of osteoarthritic hands in 20 individuals and found that illusory manipulation was beneficial in 85% of participants. Interestingly, shrinking the appearance of the hand reduced pain in some individuals whereas stretching the appearance of the hand reduced pain in others, suggesting that manipulation of size in one particular direction did not produce consistent pain reduction between individuals. Thus, clinical evidence suggests that visual distortion modulates pain but the direction of affect is variable.

Studies exposing pain-free healthy human participants to experimentally-induced pain have found that reducing the size of hands increased experimental pain report [12, 13]. Mancini et al. [12] exposed 18 individuals to experimentally-induced contact heat pain of the dorsum of the hand using a Peltier-type thermode and found that reducing the size of a mirror-reflected hand increased pain and enlarging the mirror-reflected hand reduced pain. Likewise, Romano and Maravita [13] exposed 38 individuals to blunt pressure pain to the middle finger and found that using a lens to reduce the size of the hand increased experimental pain and enlarging the hand reduced pain. At face value these findings appear to be counterintuitive. The investigators have suggested that magnifying the body part increased anticipatory reactions associated with expectancies about the intensity of the experimentally-induced noxious stimuli and that this prepares individuals for exposure to the noxious event [12, 13]. However, a study from our laboratory failed to detect differences in cold-pressor pain by reducing and enlarging the appearance of the size of a hand using mirror visual feedback in 20 healthy human participants [14]. Furthermore, Osumi et al. [15] found that on healthy participants with low thresholds to experimental pain reported unpleasant emotions towards a magnified hand and that two-point discrimination threshold decreased when the hand was magnified in participants with higher pain threshold. They suggested that visual feedback of magnified body parts only occurs in the presence of vivid tactile perception and without severe unpleasant emotions toward the magnified image.

IS EMBODIMENT OF A VIRTUAL BODY PART THE CRITICAL FACTOR?

Experimentally-induced pain techniques described above do not produce appreciable pathology, sensitisation or cortical re-organisation. Pain that is driven by pathological processes such as tissue damage, peripheral and central sensitisation and reorganisation of central nervous system neural networks often leads to the perception of enlarged body parts. Thus, it seems logical that reducing the appearance of the size of a body part decreases the perceptual experience of pain and size of the limb because of the dominance of visual over somatosensory input in determining ownership and position of body parts. McCabe [16] suggested that mirror visual feedback and associated techniques may relieve pain by creating a sense of ownership of the "virtual hand" over the painful hand. The subjective experience of having a sense of one's own body, including a sense of ownership of body parts, is termed embodiment. Research into the relationship between embodiment and pain is in its infancy but may provide useful insights into potential therapeutic approaches. Embodiment has been investigated using the rubber hand illusion whereby an individual observes a rubber hand being stroked with a brush (in view) whilst their real hand is stroked in synchrony but out of view. Eventually, usually within a few minutes, the sensation of stroking feels as if it arises from the rubber hand and the individual experiences a sense that the rubber hand is part of their body (i.e. embodiment of the rubber hand into the body schema). The "loss of the real hand" is one of the stages of embodiment of the rubber hand [17] and it is accompanied by physiological responses such as local skin cooling and histamine reactivity, proprioceptive drift and alterations of neural activity in the brain [18]. Interestingly, threatening an embodied rubber hand with noxious stimuli generates subjective anxiety and skin conductance responses that are similar in magnitude to that experienced when a real hand was threatened [19]. The strength of desire to withdraw the rubber hand from the threat is positively correlated with the intensity of embodiment. Threatening an embodied rubber hand may produce somatic sensations such as 'tingling' in some individuals.

To date, studies using visual feedback techniques have paid little attention to whether individuals have embodied the virtual limb. Recently, Medina et al. [20] found a positive correlation between perceptual embodiment of a body part reflected in a mirror and the strength of mirror illusion. So far there have been no studies examining the relationship between embodiment and the strength of the mirror distorted image of the body part. However, it seems worthwhile introducing techniques to enhance embodiment of reflected limbs when using mirror box therapy in clinical practice, such as clenching fingers of non-painful and painful hands in synchrony, whilst observing the reflection.

CONCLUSION

Research into the effect of visually distorting painful body parts is in its infancy yet initial findings suggest that such techniques may have therapeutic value. The size of a painful body part can easily be manipulated in a clinical setting using convex and concave mirrors, lenses and binoculars. It is likely that the ability of an individual to embody the 'virtual' body part into their body schema will influence outcome. Moreover, there are other aspects of the visual appearance of painful body parts that can be manipulated such as dimensions, colour and texture. Virtual reality environments may prove valuable to achieve such manipulations. Virtual reality is also a powerful tool to facilitate embodiment of body parts. At present, virtual reality techniques are limited to research settings because of the need for specialised equipment and software. However, virtual reality can now be delivered through mobile phones and specially adapted glasses frames such as Google Cardboard. It seems a logical next step to us to develop software that can manipulate the appearance of painful body parts and uploaded onto a patient's mobile telephone so that they can self-administer visual feedback therapy. It is important that research into the clinical efficacy and utility of these potentially useful visual feedback techniques is undertaken.

KEYWORDS

Pain, Chronic Pain, Pain Management, Rehabilitation, Body Image, Embodiment, Visual Illusion, Visual Distortion, Mirror Visual Feedback, Virtual Reality

REFERENCES

1. Moseley GL. I can't find it! Distorted body image and tactile dysfunction in patients with chronic back pain. *Pain* 140(1), 239-243 (2008).
2. Ramachandran VS, Rogers-Ramachandran D, Cobb S. Touching the phantom limb. *Nature* 377(6549), 489-490 (1995).
3. Chan BL, Witt R, Charrow AP *et al*. Mirror therapy for phantom limb pain. *N Engl J Med* 357(21), 2206-2207 (2007).
4. Moseley GL. Using visual illusion to reduce at-level neuropathic pain in paraplegia. *Pain* 130(3), 294-298 (2007).
5. Sayegh S, Filén T, Johansson M, Sandström S, Stiewe G, Butler S. Mirror therapy for Complex Regional Pain Syndrome (CRPS). A literature review and an illustrative case report. *Scandinavian Journal of Pain* 4 200–207 (2013).
6. Ramachandran VS, Seckel EL. Using mirror visual feedback and virtual reality to treat fibromyalgia. *Med Hypotheses* 75(6), 495-496 (2010).
7. Daffada PJ, Walsh N, Mccabe CS, Palmer S. The impact of cortical remapping interventions on pain and disability in chronic low back pain: A systematic review. *Physiotherapy* (2014).
8. Lamont K, Chin M, Kogan M. Mirror box therapy: seeing is believing. *Explore (NY)* 7(6), 369-372 (2011).
9. Moseley GL, Parsons TJ, Spence C. Visual distortion of a limb modulates the pain and swelling evoked by movement. *Curr Biol* 18(22), R1047-1048 (2008).
10. Diers M, Zieglgansberger W, Trojan J, Drevensek AM, Erhardt-Raum G, Flor H. Site-specific visual feedback reduces pain perception. *Pain* 154(6), 890-896 (2013).
11. Preston C, Newport R. Analgesic effects of multisensory illusions in osteoarthritis. *Rheumatology (Oxford)* 50(12), 2314-2315 (2011).
12. Mancini F, Longo MR, Kammers MP, Haggard P. Visual distortion of body size modulates pain perception. *Psychol Sci* 22(3), 325-330 (2011).
13. Romano D, Maravita A. The visual size of ones own hand modulates pain anticipation and perception. *Neuropsychologia* 57 93-100 (2014).
14. Johnson M, Gohil M. An investigation into enlarging and reducing the size of mirror reflections of the hand on experimentally-induced cold-pressor pain in healthy human participants. *Scandinavian Journal of Pain* 10 19-25 (2016 [ePub 2015]).
15. Osumi M, Imai R, Ueta K, Nakano H, Nobusako S, Morioka S. Factors associated with the modulation of pain by visual distortion of body size. *Front Hum Neurosci* 8 137 (2014).

16. Mccabe C. Mirror visual feedback therapy. A practical approach. *J Hand Ther* 24(2), 170-178; quiz 179 (2011).
17. Lewis E, Lloyd DM. Embodied experience: A first-person investigation of the rubber hand illusion. *Phenomenol Cogn Sci* 9(3), 317-339 (2010).
18. Moseley GL, Olthof N, Venema A *et al*. Psychologically induced cooling of a specific body part caused by the illusory ownership of an artificial counterpart. *Proc Natl Acad Sci U S A* 105(35), 13169-13173 (2008).
19. Ehrsson HH, Wiech K, Weiskopf N, Dolan RJ, Passingham RE. Threatening a rubber hand that you feel is yours elicits a cortical anxiety response. *Proc Natl Acad Sci U S A* 104(23), 9828-9833 (2007).
20. Medina J, Khurana P, Coslett HB. The influence of embodiment on multisensory integration using the mirror box illusion. *Conscious Cogn* 37 71-82 (2015).